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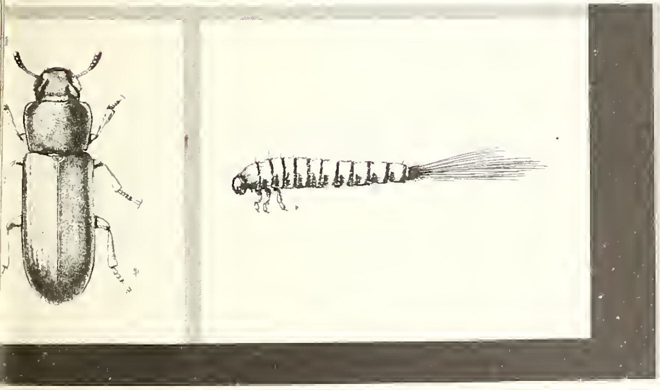
# Contact, Residue, and Vapor Toxicity of New Insecticides to Stored-Product Insects



Market Quality Research Division
Agricultural Marketing Service
U.S. DEPARTMENT OF AGRICULTURE

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## ACKNOWLEDGMENTS

The research program described in this report was initiated under the direction of Hamilton Laudani and continued under Dean F. Davis, both former Station Leaders at the Stored-Product Insects Laboratory at Savannah, Ga. Mr. Laudani is now Assistant Chief and Mr. Davis is now Developmental Research Group Leader, Stored-Product Insects Branch, Beltsville, Md. Gerald Eason and Mims Oglesby, Jr., laboratory technicians, assisted in conducting this research. A. H. Yeomans, now with the Pesticide Chemicals Research Branch, Entomology Research Division, Agricultural Research Service, conducted the exploratory tests leading to the design of the insecticide settling towers. The initial biological tests were conducted by B. H. Kantack, now with the Agricultural Experiment Station, University of Nebraska, Lincoln, Nebr. Mrs. E. M. Osborne, Pesticide Chemicals Research Branch, verified the nomenclature of the compounds.

Washington, D. C. June 1962

# CONTACT, RESIDUE, AND VAPOR TOXICITY OF NEW INSECTICIDES TO STORED-PRODUCT INSECTS

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## SUMMARY

Twenty-two compounds were tested and evaluated to determine their direct-contact, residue, and vapor toxicity to flour beetle adults, Tribolium spp., and black carpet beetle larvae, Attagenus piceus (Oliv.). The most promising compounds 2/ were: Bayer 18510, 16574, 19641, dicapthon, and Union Carbide 8305 for direct-contact toxicity; dicapthon, Union Carbide 8305, and Bayer 16574 for residue toxicity; and dicapthon, Bayer 13242, 16574, 16900, 16948, 20743, 18780, and 19641, Di-Syston, and Union Carbide 8305 for vapor toxicity. Aging tests of the residues showed that the more persistent compounds were dicapthon, Bayer 19596, Bayer 18786, and Phostex.

## INTRODUCTION

There is a great need for more effective, safer, and less costly insecticides for protecting food, feed, seed, and other agricultural commodities against insect infestation. The Stored-Product Insects Branch of the Agricultural Marketing Service conducts a program of basic evaluation of insecticides at the Stored-Product Insects Laboratory, Savannah, Ga. The primary function of this program is to determine the comparative effectiveness of new compounds on representative species of stored-product insects. On the basis of this information, new insecticidal chemicals can be selected for further evaluation in specific control programs under many other research projects of the Branch.

In the first tests, flour beetle adults, Tribolium spp., and black carpet beetle larvae, Attagenus piceus (Oliv.), were used. These two species were selected because the flour beetle adults represent approximately the median of the range of susceptibility of stored-product insects to insecticides and the black carpet beetle larvae represent a low order of susceptibility. Another reason was that these two species are easy to handle under test conditions.

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1/ This laboratory is a field station of the Stored-Product Insects Branch, Market Quality Research Division, Agricultural Marketing Service, U. S. Department of Agriculture.

2/ The use of trade names in this report is for identification purposes only and does not constitute endorsement of the products by the U. S. Department of Agriculture.

The 22 compounds evaluated in this report were the first compounds evaluated in this program. The compounds tested were as follows 3/:

| ENT-No. 4/ | Company Name | Chemical Abstracts Name |
|---|---|---|
| 24987 | Bayer 13242 | Phosphorazidothioic acid, *O*,*O*-diethyl ester |
| 22016 | Bayer 16574 | Phosphoric acid, 2-chloroethyl 2,2-dichlorovinyl ethyl ester |
| 23283 | Bayer 16900 | Phosphorothioic acid, *O*-(ethoxycarbonylmethylthio)ethyl *O*,*O*-diethyl ester |
| 22734 | Bayer 16948 | Phosphorothioic acid, *O*,*O*-diethyl *O*-2-(sec-butoxymethylthio)ethyl ester |
| 22738 | Bayer 18220 | Benzenesulfonic acid, *p*-chloro-, 3,4-dichlorobenzyl ester |
| 22751 | Bayer 18341 | Phosphorodithioic acid, *S*-(*p*-chlorobenzyl) *O*,*O*-diethyl ester |
| 23438 | Bayer 18510 | Phosphorothioic acid, *S*-(*alpha*-ethoxycarbonylbenzyl) *O*,*O*-dimethyl ester |
| 23445 | Bayer 18613 | Phosphorothioic acid, *O*-(ethoxycarbonyl)methyl *O*,*O*-diethyl ester |
| 23509 | Bayer 18780 | Phosphorodithioic acid, *S*-(*p*-chlorobenzyl) *O*,*O*-dimethyl ester |
| 23510 | Bayer 18781 | Phosphorodithioic acid, *S*-(*p*-chlorobenzyl) *O*,*O*-dipropyl ester |
| 23511 | Bayer 18786 | Phosphorodithioic acid, *S*-(*p*-chlorobenzyl) *O*,*O*-diisopropyl ester |
| 23440 | Bayer 18935 | Phosphorothioic acid, *O*,*O*-diethyl *O*-2-(diethylaminoethyl) ester |
| 23436 | Bayer 19596 | Phosphorodithioic acid, *S*-(ethoxycarbonylcarbamoyl)methyl *O*,*O*-diethyl ester |
| 23446 | Bayer 19641 | Phosphorodithioic acid, *S*-(*alpha*-cyanobenzyl) *O*,*O*-diethyl ester |

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3/ Single hyphens in these names should be used as shown; double hyphens indicate that the words should be closed up if written consecutively.

4/ Code number assigned by Entomology Research Division, Agricultural Research Service, to compounds distributed for screening.

| ENT-No. [4] | Company Name | Chemical Abstracts Name |
|---|---|---|
| 23439 | Bayer 19994 | Phosphorothioic acid, *O,O*-diethyl O-2-(2-pyridyl)ethyl ester |
| 23442 | Bayer 20172 | Phosphorothioic acid, *O,O*-diethyl ester, anhydride with *N,N*-bis(dimethylamidophosphate) |
| 23443 | Bayer 20743 | Xanthic acid, ethyl-, *S*-(ethylthio)methyl ester |
| 17035 | Dicapthon (American Cyanamid 4124) | Phosphorothioic acid, *O*-(2-chloro-4-nitrophenyl) *O,O*-dimethyl ester |
| 23437 | Di-Syston (Bayer 19639) | Phosphorodithioic acid, *O,O*-diethyl *S*-2-(ethylthio)ethyl ester |
| 17034 | Malathion | Phosphorodithioic acid, *S*-[1,2-bis (ethoxycarbonyl)ethyl] *O,O*-dimethyl ester |
| 23584 | Phostex (Niagara 1137) | A mixture of bis(dialkyloxyphosphinothioyl) disulfides |
| 23969 | Sevin (Union Carbide 7744) | Carbamic acid, methyl-, 1-naphthyl ester |
| 23970 | Union Carbide 8305 | 2,4-3-Dioxa-phosphabicyclo[4.4.0]decane, *p*-chloro-5-methyl-*p*-thio |

## PROCEDURE

### Direct-Contact Toxicity

The direct-contact toxicity of the experimental compounds was determined by using solutions of technical-grade material in a 50-50 mixture (w/w) of Deobase and tetrachloroethylene (acetone was used in place of tetrachloroethylene with Bayer compounds 13242, 18781, and Di-Syston). These solutions were applied to the insects as aerosols inside cylindrical stainless steel settling towers in the same manner as that described by Kantack and Laudani [5]. The formulations used in most of the tests had a concentration of 1.7, 6.8, and 20.4 mg. of insecticide per milliliter of the solution, which would give theoretical rates of application of 0.75, 3.0, and 9.0 mg./sq. ft., respectively. The concentrations varied somewhat in the early tests, however, because procedures were still being developed. Those concentrations that were used in the earlier evaluations but were altered or discontinued in subsequent tests were 3.4, 5.7, 11.4, 13.6, 22.9, 33.6, and 57.0 mg. of insecticide per milliliter of the solution, which would give theoretical rates of application of 1.5, 2.6, 5.1, 6.0, 10.2, 15.0, and 25.5 mg./sq. ft. In order to get some of the compounds into solution in the desired concentrations, it was necessary to replace some of the solvent mixture with ethanol. The experimental compounds with the percentages of ethanol in the solutions were as follows: Bayer 16900, 10 percent; Bayer 16948, 50 percent; Bayer 18220, 50 percent; Bayer 19596, 10 percent; Bayer 19641, 10 percent; and Sevin, 50 percent. The solutions of dicapthon contained 3 percent of acetone and 3 percent of glacial acetic acid by weight. Malathion was used as a standard for comparison. Untreated insects were used as checks in all tests and, in addition, solvent-treated insects in most of them.

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[4] Code number assigned by Entomology Research Division, Agricultural Research Service, to compounds distributed for screening.

[5] Kantack, Ben H., and Laudani, Hamilton. Comparative Laboratory Tests with Emulsion and Wettable-Powder Residues Against the Indian-Meal Moth. Jour. Econ. Ent. 50(4):513-514. August 1957.

The insecticide settling towers used in the direct-contact toxicity evaluation tests are shown in figures 1 through 4. The dimensions of the towers were limited by the spray pattern of the nozzles used. The 6-foot height and 2-foot diameter were such that a very even distribution of spray particles was obtained on the tower floor and a minimum of impingement occurred on the walls of the towers. Nozzles were placed in an opening at the center of the top, and the test insecticides were pipetted directly into the nozzles. After the desired settling period had elapsed, the exhaust baffle at the top was opened, the vent at the floor was opened, and the test insects were removed through the bottom vent door.

The flour beetle adults used in the test were Tribolium confusum Duv. and T. castaneum (Hbst.), 3 to 30 days old. These insects were reared on a medium consisting of 50 percent of white wheat flour, 45 percent of corn meal, and 5 percent of brewer's yeast. The black carpet beetle larvae were 3 to 5 months old and were reared on ground Purina Laboratory Chow.

The test insects were placed in open petri dishes (10 insects per dish). The bottoms of all petri dishes to contain flour beetles for exposure and post-exposure were covered with kraft paper to give the insects footing. Four dishes of each species were placed on the kraft paper-covered floor in each of four towers. The bottom vent door and the top exhaust baffle were closed, and 2 milliliters of the experimental insecticide solution being tested was introduced. A Spraying Systems Co. air atomizing nozzle No. 1/4 J-2850-70, using 10 p.s.i. air pressure, was used for most of the compounds, and No. 1/4 J-1650-54 was used with Bayer compounds 13242, 18781, and Di-Syston. The aerosols were allowed to settle for 30 minutes. The room in which the towers were located was maintained at a temperature of 75° to 80° F. during all tests. Previous tests had shown that most of the particles settling on the floor were from 5 to 10 microns in size and that about 70 percent of the insecticide settled out in 30 minutes.

After exposure, the insects were removed from the towers, transferred to clean petri dishes, and held for post-exposure observation in a room maintained at a temperature of 80° F. ± 2° and a relative humidity of 60 ± 5 percent. Inactive and dead and moribund insects were counted at various intervals.

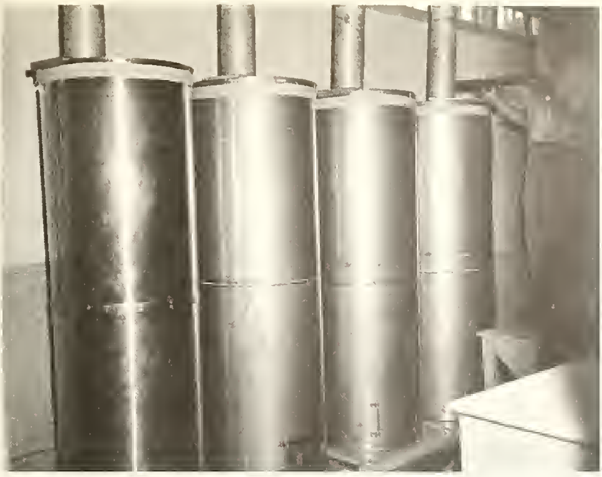

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Figure 1.--Insecticide settling towers used in the preliminary evaluation of new insecticides against stored-product insects. Entomologist, at far right, prepares to introduce insecticide into top of end tower.

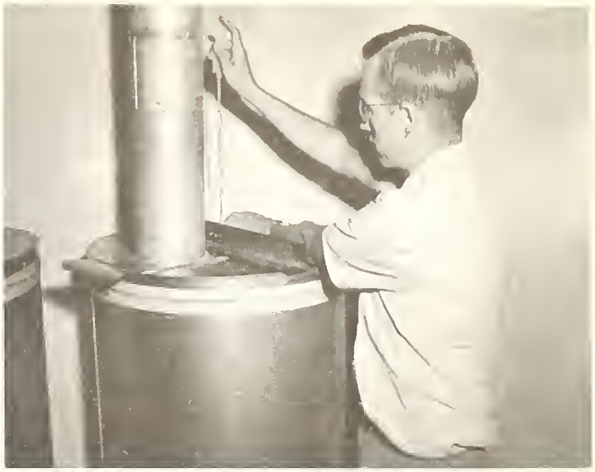

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Figure 2.--Entomologist introducing insecticide into top of settling tower.

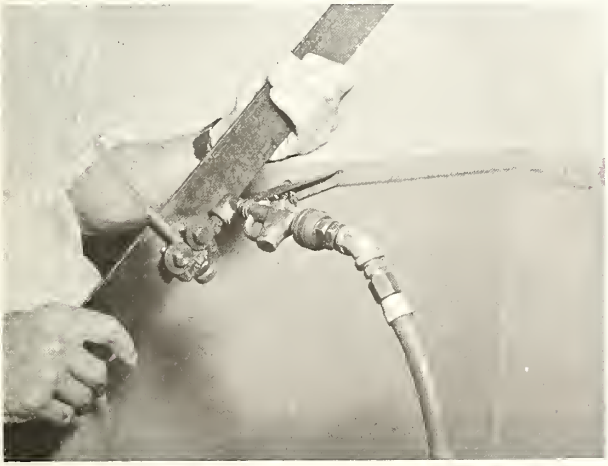

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Figure 3.--Nozzle used at top of insecticide settling tower to introduce insecticide formulations into the tower.

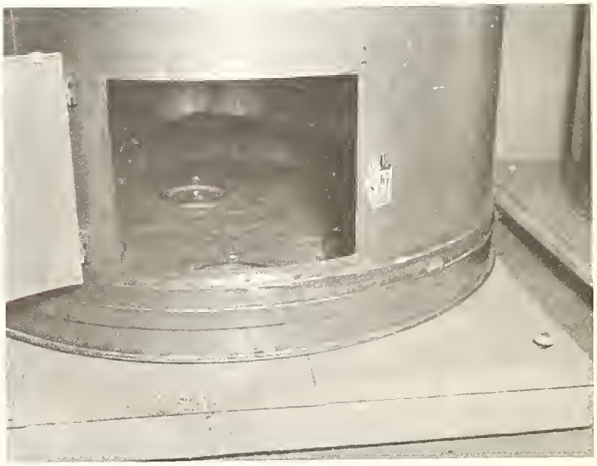

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Figure 4.--Bottom door of insecticide settling tower, showing petri dishes that contained test insects during exposure to insecticide.

The towers were aired, using forced air movement, for 10 minutes after each exposure. Clean kraft paper was placed on the floor of the towers at each change to a different insecticide. The towers were periodically disassembled and washed with water and acetone.

## Residue Toxicity

The residue toxicity of the experimental compounds was determined by applying solutions of the compounds to surfaces and then confining the insects on the treated surfaces by use of open-end glass cylinders.

The first two compounds tested in this group (Bayer 18781 and Di-Syston) were formulated as solutions in a solvent mixture of equal parts of acetone and Deobase. Six milliliters of each solution was applied to 1/8-inch-thick untempered Masonite panels (3 by 12 inches) by use of a #1 acid swab brush to give rates of application of 16, 32, 64, and 96 mg./sq. ft. In subsequent tests, the compounds were formulated in acetone, and 1 milliliter was applied by use of a Gardner Automatic Blade Applicator to 3- by 12-inch sheets of 15-pound kraft paper laminated to 0.00035-inch-thick aluminum foil to give rates of 10, 50, and 100 mg./sq. ft. (fig. 5) 6/. The paper side was used as an absorbent surface and the aluminum side as a nonabsorbent surface. Malathion was used as a standard for comparison. Acetone-treated sheets were used as checks.

Four sheets of each surface at each rate of application were treated. The treated papers were stapled to Celotex boards and stored in a warehouse in which temperature and humidity were not controlled. Two sheets of each surface (one for each species of test insect) were set up with insects 24 hours after treatment, and the other two sheets were tested 28 days after treatment (no 28-day aging was conducted with the first four compounds tested: Bayer compounds 13242, 16574, 18781, and Di-Syston). The treated strips were removed from the boards and placed on tables with the treated surface up. Four open-end glass cylinders were placed on each treated surface. Ten insects were placed inside each cylinder. One sheet for each species of test insect was used for each treatment. A 4-hour exposure period was used for the flour beetles immediately after the insecticide had been applied. A 24-hour exposure period was used for the flour beetles in the aging test and for the black carpet beetle larvae both in the exposures immediately after application of the insecticide and in the 28-day aging tests. After exposure, the insects were transferred to clean petri dishes. The bottoms of those that were to contain flour beetles were covered with kraft paper. The inactive and dead and moribund insects were counted at various intervals (tables 2, 3, 4, and 5). Exposure and post-exposure tests were conducted in a room maintained at a temperature of 80° F. ± 2° and a relative humidity of 60 ± 5 percent.

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6/ Stored-Product Insects Laboratory. Laboratory Evaluation of Promising Compounds as Repellents to Flour Beetles, Tribolium spp. Mktg. Res. Rpt. 324, 46 pp. 1959.

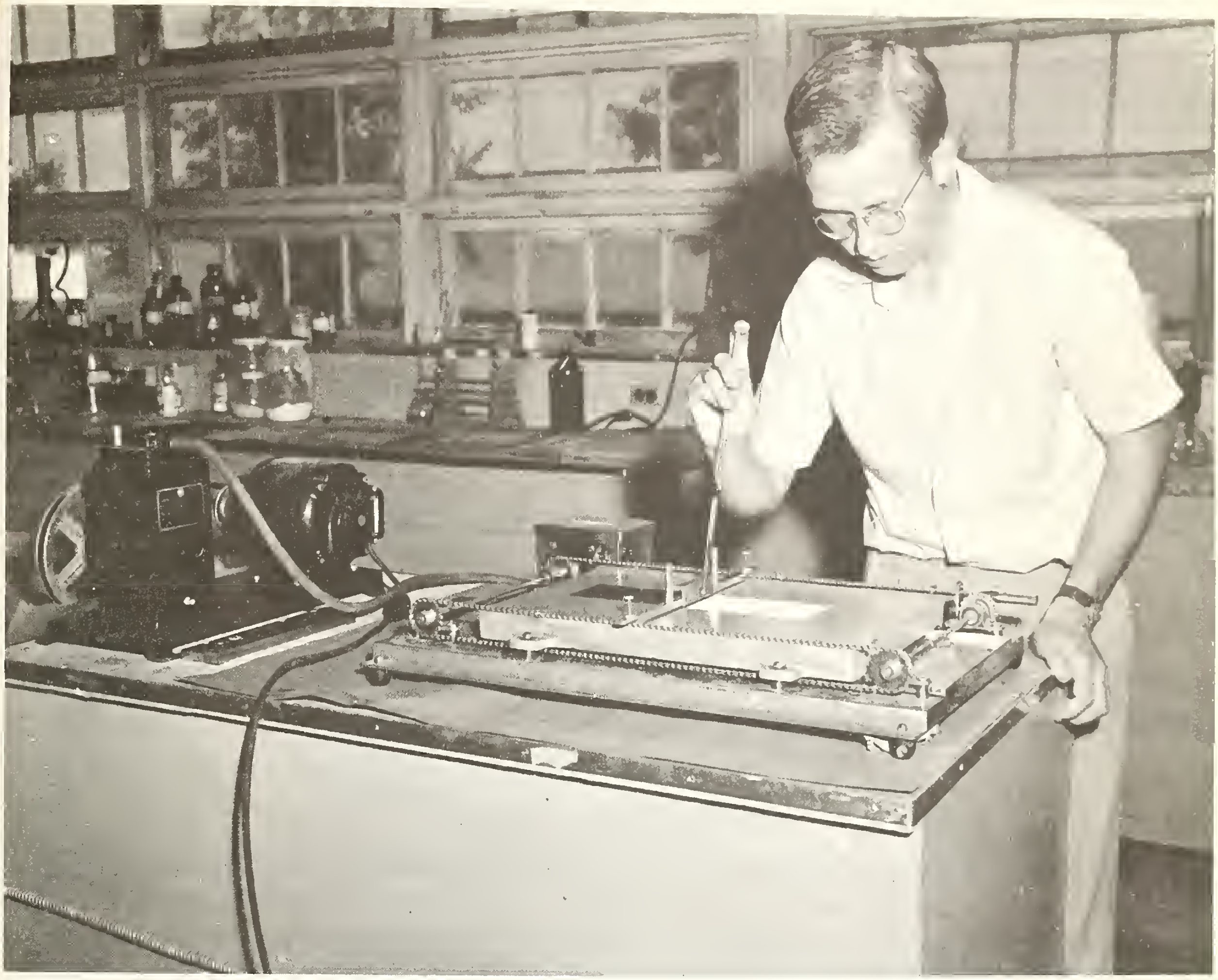

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Figure 5.--Application of insecticide to paper surface for use in residue evaluation tests. Uniform application is obtained with the Gardner Automatic Blade Applicator.

### Vapor Toxicity

The vapor action of the experimental compounds was determined by use of the jar test technique described by Laudani [7]. The tests were conducted in a room maintained at a temperature of 80° F. ± 2° and a relative humidity of 60 ± 5 percent. The experimental compounds were formulated in acetone. Four milliliters were introduced into each test jar. Malathion and lindane were used as standards for comparison, and acetone-treated jars were used as checks. The jars were stored open for 24 hours before setting up the test, to allow the acetone to volatilize completely. The rate of application was 192 mg./sq. ft. for the first four compounds tested and 200 mg./sq. ft. for the others. Ten insects were placed in each crystallizing dish (the bottoms of the dishes that were to contain flour beetles were covered with paper). A canopy, made by cutting the sides from a waxed paper cup, covered each dish to prevent crystals of the insecticide from falling into the crystallizing dishes containing the insects. Dishes thus prepared were placed on lids, and the treated jars were inverted over the dishes on the lids. Four replicate jars were tested for each insecticide. Determinations of the number of inactive and dead and moribund insects were made at various intervals of exposure (table 6).

## RESULTS

The results of initial tests with flour beetle adults and black carpet beetle larvae are shown in graphs in figures 6 and 7. The detailed data are presented in tables 1 through 6.

### Direct-Contact Toxicity

Bayer 16574, Union Carbide 8305, and dicapthon were the most effective compounds tested in contact action against flour beetle adults (table 1).

The most effective compounds in direct-contact toxicity to black carpet beetle larvae of those tested were Bayer 18510, 16574, and 19641, and dicapthon, in the order named (table 1).

### Residue Toxicity

Exposure tests of flour beetle adults to paper surfaces treated with each of the experimental compounds revealed that residues of dicapthon, Bayer 16574, and Union Carbide 8305 were the most effective (table 2). In similar tests on aluminum surfaces, dicapthon, Bayer 16900, 16948, 18220, 18510, 18786, and 19641, Union Carbide 8305, and Phostex had the most effective

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[7] Laudani, Hamilton, Evaluation of Strobane and Perthane as Protectants for Woolens Against Fabric Insect Damage and as Toxicants in Controlling Black Carpet Beetles. Soap & Chem. Spec. 31(8):149, 151, 153, 177, 179, 181. August 1955.

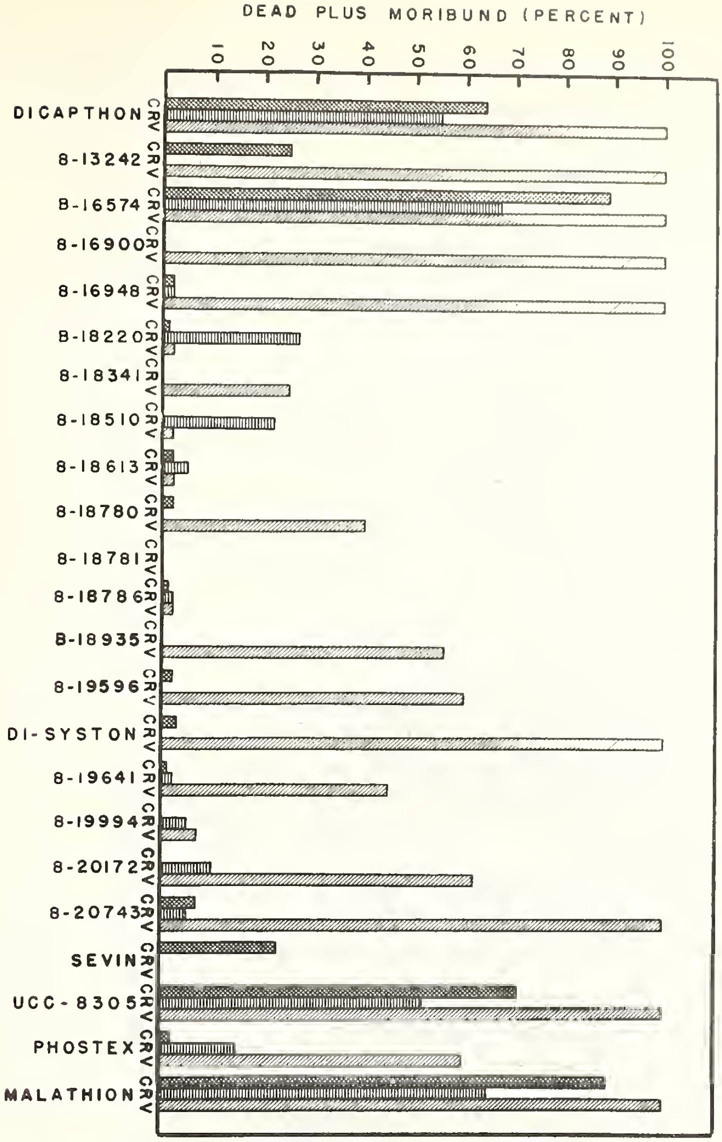

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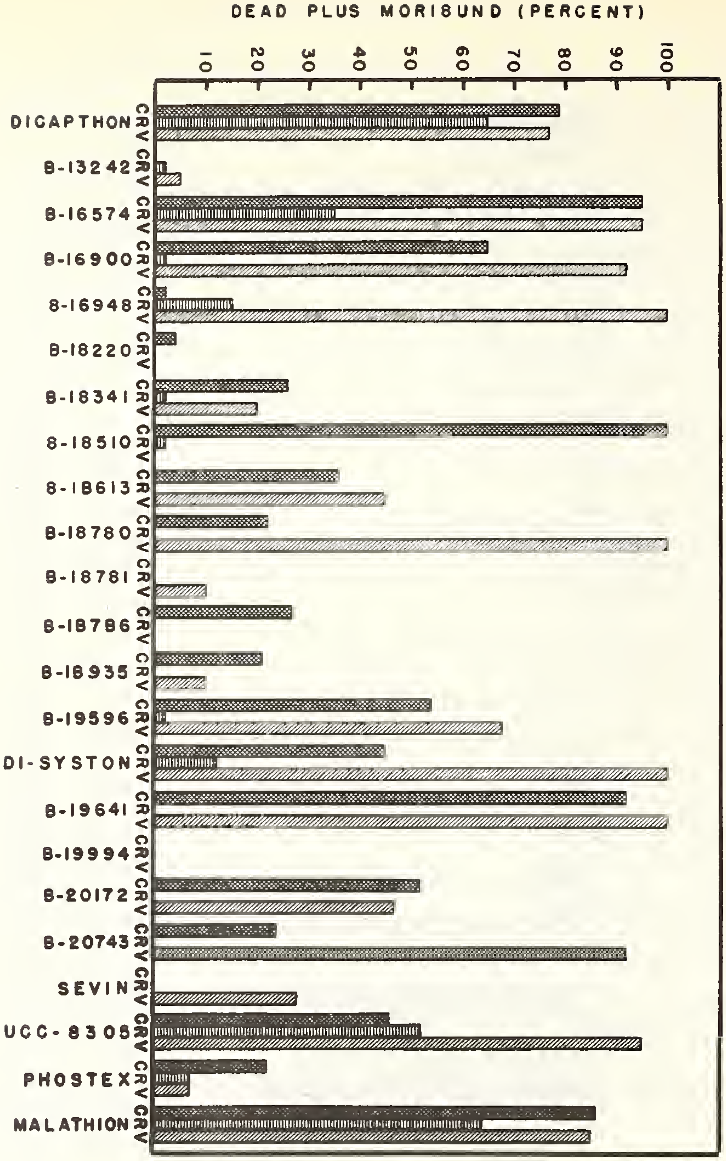
Figure 6.--The direct-contact (C), residue (R), and vapor (V) action of 22 experimental compounds and malathion on adult flour beetles; insects exposed for 1/2 hour to aerosols in the direct-contact tests, for 4 hours to residues on paper surfaces in residue tests, and continuous exposure in the vapor tests. Rates of application were 0.75 mg./sq. ft. in contact, 10 mg./sq. ft. in residue, and 200 mg./sq. ft. in the vapor tests. Readings were taken at 120 hours after exposure had ended for contact and residue and after 120 hours' exposure for the vapor tests (B: Bayer; UCC: Union Carbide).



BN-15664

Figure 7.--The direct-contact (C), residue (R), and vapor (V) action of 22 experimental compounds and malathion to black carpet beetle larvae; insects exposed for 1/2 hour to aerosols in the direct contact tests, for 24 hours to residues on paper surfaces in residue tests, and continuous exposure in the vapor tests. Rates of application were 0.75 mg./sq. ft. in contact, 50 mg./sq. ft. in residue, and 200 mg./sq. ft. in the vapor tests. Readings were taken at 336 hours after exposure had ended for contact, 168 hours for residue, and after 360 hours' exposure for the vapor tests (B: Bayer; UCC: Union Carbide).

residues (table 3). Tests with insects on paper surfaces 28 days after application of the insecticides showed that the toxicity of residues of dicapthon and Bayer 19596 was more persistent on paper than that of residues of the other compounds tested (table 4). Tests with insects on aluminum surfaces showed that the residues more persistent on aluminum were those of dicapthon, Bayer 18786, and Phostex (table 5).

Exposure of black carpet beetle larvae to residues of the various compounds on paper showed that residues of dicapthon and Union Carbide 8305 produced the highest toxicity values (table 2), and dicapthon also had the most effective residue on aluminum (table 3). In aging tests of residues on both paper and aluminum, conducted 28 days after application of the insecticides, dicapthon was the only compound tested that had significant residue toxicity to black carpet beetle larvae (tables 4 and 5).

### Vapor Toxicity

Several of the compounds showed high vapor toxicity to flour beetle adults and black carpet beetle larvae. Outstanding against the flour beetle were dicapthon, Bayer 13242, 16574, 16900, 16948, Di-Syston, Bayer 20743, and Union Carbide 8305 (table 6). The most effective vapor toxicants against the black carpet beetle were Bayer 16948, 18780, Di-Syston, and Bayer 19641 (table 6).

## CONCLUSIONS

The results of these evaluation tests will enable researchers in control investigations of stored-product insects on specific commodities to select those compounds that show the most promise in a particular type of action. Considered highly promising are dicapthon, Bayer 16574, and Union Carbide 8305. Follow-up field evaluations of these materials are recommended. Bayer 16574, 18510, and 19641 appear to be highly promising for direct application in the control of dermestids.

Table 1.--Percentage of adult flour beetles and black carpet beetle larvae inactive or dead and moribund after a $\frac{1}{2}$-hour exposure to an experimental compound in aerosol form

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 336 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 13242 | 25.5 | 100 | 100 | 100 | 100 | 100 | 36 | 100 | 100 |
| | 10.2 | 100 | 100 | 100 | 100 | 100 | 0 | 75 | 57 |
| | 5.1 | 89 | 19 | 82 | 78 | 7 | 0 | 5 | 3 |
| | 2.6 | 24 | 4 | 25 | 25 | 1 | 0 | 0 | 0 |
| Bayer 16574 | 15.0 | 100 | 91 | 100 | 100 | 100 | 6 | 100 | 95 |
| | 6.0 | 100 | 88 | 100 | 100 | 100 | 9 | 100 | 97 |
| | 3.0 | 100 | 82 | 100 | 100 | 100 | 3 | 100 | 96 |
| | 1.5 | 93 | 59 | 89 | 89 | 100 | 5 | 100 | 95 |
| Bayer 16900 | 9.0 | 99 | 99 | 99 | 99 | 98 | 0 | 100 | 76 |
| | 3.0 | 65 | 50 | 84 | 62 | 84 | 0 | 100 | 63 |
| | .75 | 0 | 0 | 0 | 0 | 94 | 0 | 100 | 65 |
| Bayer 16948 | 9.0 | 100 | 100 | 100 | 100 | 98 | 0 | 100 | 88 |
| | 3.0 | 66 | 52 | 66 | 66 | 63 | 0 | 54 | 30 |
| | .75 | 0 | 0 | 2 | 2 | 0 | 0 | 8 | 2 |
| Bayer 18220 | 9.0 | 0 | 0 | 0 | 0 | 2 | 0 | 6 | 0 |
| | 3.0 | 0 | 0 | 2 | 2 | 4 | 0 | 2 | 0 |
| | .75 | 0 | 0 | 1 | 1 | 1 | 0 | 14 | 4 |
| Bayer 18341 | 9.0 | 0 | 0 | 1 | 1 | 51 | 0 | 86 | 60 |
| | 3.0 | 0 | 0 | 1 | 1 | 13 | 0 | 18 | 13 |
| | .75 | 0 | 0 | 0 | 0 | 25 | 0 | 34 | 26 |
| Bayer 18510 | 9.0 | 100 | 95 | 100 | 100 | 100 | 0 | 100 | 100 |
| | 3.0 | 83 | 59 | 87 | 87 | 100 | 0 | 100 | 100 |
| | .75 | 0 | 0 | 0 | 0 | 100 | 0 | 100 | 100 |
| Bayer 18613 | 9.0 | 0 | 0 | 2 | 2 | 95 | 0 | 94 | 80 |
| | 3.0 | 0 | 0 | 2 | 2 | 33 | 0 | 38 | 33 |
| | .75 | 1 | 1 | 2 | 2 | 17 | 0 | 38 | 36 |

(Continued)

Table 1.--Percentage of adult flour beetles and black carpet beetle larvae inactive or dead and moribund after a $\frac{1}{2}$-hour exposure to an experimental compound in aerosol form--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 336 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 18780..... | 9.0 | 78 | 16 | 79 | 66 | 2 | 1 | 4 | 1 |
| | 3.0 | 66 | 7 | 52 | 31 | 0 | 0 | 10 | 1 |
| | .75 | 1 | 0 | 2 | 2 | 8 | 1 | 31 | 22 |
| Bayer 18781..... | 25.5 | 0 | 0 | 3 | 2 | 21 | 0 | 47 | 47 |
| | 10.2 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 2 |
| | 5.1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 2.6 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Bayer 18786..... | 9.0 | 0 | 0 | 0 | 0 | 22 | 0 | 38 | 20 |
| | 3.0 | 0 | 0 | 2 | 2 | 25 | 0 | 34 | 21 |
| | .75 | 0 | 0 | 1 | 1 | 28 | 0 | 32 | 27 |
| Bayer 18935..... | 9.0 | 0 | 0 | 0 | 0 | 62 | 39 | 68 | 49 |
| | 3.0 | 0 | 0 | 0 | 0 | 71 | 22 | 72 | 52 |
| | .75 | 0 | 0 | 0 | 0 | 26 | 0 | 32 | 21 |
| Bayer 19596..... | 9.0 | 8 | 8 | 9 | 9 | 97 | 0 | 100 | 59 |
| | 3.0 | 0 | 0 | 0 | 0 | 93 | 0 | 90 | 46 |
| | .75 | 0 | 0 | 2 | 2 | 86 | 0 | 82 | 54 |
| Bayer 19641..... | 9.0 | 96 | 78 | 91 | 91 | 100 | 88 | 100 | 98 |
| | 3.0 | 2 | 2 | 2 | 2 | 100 | 71 | 100 | 96 |
| | .75 | 0 | 0 | 1 | 1 | 100 | 67 | 100 | 92 |
| Bayer 19994..... | 9.0 | 0 | 0 | 2 | 2 | 40 | 0 | - | - |
| | 3.0 | 0 | 0 | 0 | 0 | 35 | 0 | - | - |
| | .75 | 0 | 0 | 0 | 0 | 10 | 0 | - | - |
| Bayer 20172..... | 9.0 | 1 | 1 | 2 | 2 | 78 | 76 | 100 | 94 |
| | 3.0 | 0 | 0 | 5 | 5 | 90 | 34 | 100 | 94 |
| | .75 | 0 | 0 | 0 | 0 | 76 | 32 | 76 | 52 |

(Continued)

Table 1.--Percentage of adult flour beetles and black carpet beetle larvae inactive or dead and moribund after a $\frac{1}{2}$-hour exposure to an experimental compound in aerosol form--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 336 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 20743..... | 9.0 | 0 | 0 | 4 | 4 | 19 | 0 | 20 | 9 |
| | 3.0 | 0 | 0 | 0 | 0 | 15 | 0 | 34 | 20 |
| | .75 | 2 | 2 | 7 | 7 | 27 | 0 | 40 | 24 |
| Dicapthon....... | 9.0 | 100 | 100 | 100 | 100 | 96 | 8 | 100 | 96 |
| | 3.0 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 84 |
| | .75 | 80 | 54 | 64 | 64 | 100 | 0 | 100 | 79 |
| Di-Syston....... | 25.5 | 100 | 99 | 100 | 100 | 100 | 75 | 100 | 100 |
| | 10.2 | 94 | 92 | 94 | 93 | 96 | 15 | 98 | 73 |
| | 5.1 | 34 | 23 | 32 | 32 | 89 | 12 | 94 | 66 |
| | 2.6 | 4 | 1 | 3 | 3 | 55 | 7 | 62 | 45 |
| Malathion 2/.... | 9.0 | 100 | 100 | 100 | 100 | 99 | 0 | 100 | 98 |
| | 3.0 | 92 | 74 | 90 | 86 | 100 | 1 | 100 | 99 |
| | .75 | 90 | 82 | 92 | 89 | 91 | 9 | 100 | 86 |
| Phostex......... | 9.0 | 0 | 0 | 2 | 2 | 68 | 0 | 84 | 45 |
| | 3.0 | 0 | 0 | 2 | 2 | 24 | 0 | 26 | 31 |
| | .75 | 0 | 0 | 2 | 2 | 18 | 0 | 22 | 22 |
| Sevin........... | 9.0 | 96 | 66 | 94 | 86 | 17 | 0 | 6 | 0 |
| | 3.0 | 54 | 22 | 50 | 47 | 0 | 0 | 5 | 0 |
| | .75 | 29 | 18 | 24 | 23 | 1 | 0 | 3 | 0 |
| Union Carbide 8305.......... | 9.0 | 100 | 80 | 100 | 100 | 100 | 43 | 100 | 65 |
| | 3.0 | 100 | 70 | 100 | 100 | 100 | 42 | 100 | 56 |
| | .75 | 76 | 45 | 76 | 71 | 100 | 17 | 100 | 46 |
| Check (solvent) 3/ | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 1 |

1/ I=inactive; D+M=dead and moribund.

2/ Malathion data for 9.0, 3.0, and 0.75 mg./sq. ft. are averages from 5, 6, and 13 tests, respectively. 3/ Check data are averages of 13 tests.

Table 2.--Percentage of inactive or dead and moribund insects among adult flour beetles exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after an experimental compound had been applied to the paper

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 13242..... | 100 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 16574..... | 100 | 100 | 100 | 100 | 100 | 100 | 27 | 100 | 40 |
| | 50 | 100 | 100 | 100 | 100 | 80 | 0 | 90 | 35 |
| | 10 | 67 | 67 | 67 | 67 | 15 | 0 | 0 | 0 |
| Bayer 16900..... | 100 | 100 | 100 | 100 | 100 | 2 | 0 | 2 | 0 |
| | 50 | 32 | 19 | 24 | 24 | 2 | 2 | 2 | 2 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 16948..... | 100 | 100 | 100 | 100 | 100 | 15 | 0 | 10 | 7 |
| | 50 | 72 | 45 | 65 | 65 | 52 | 0 | 48 | 15 |
| | 10 | 0 | 0 | 2 | 2 | 7 | 0 | 5 | 5 |
| Bayer 18220..... | 100 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 15 | 15 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 27 | 27 | 0 | 0 | 0 | 0 |
| Bayer 18341..... | 100 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 2 |
| | 10 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Bayer 18510..... | 100 | 65 | 25 | 68 | 65 | 48 | 8 | 42 | 22 |
| | 50 | 7 | 3 | 12 | 12 | 2 | 0 | 5 | 2 |
| | 10 | 22 | 22 | 22 | 22 | 5 | 0 | 12 | 5 |
| Bayer 18613..... | 100 | 2 | 2 | 7 | 7 | 0 | 0 | 0 | 0 |
| | 50 | 2 | 2 | 7 | 7 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |

(Continued)

Table 2.--Percentage of inactive or dead and moribund insects among adult flour beetles exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after an experimental compound had been applied to the paper--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 18780..... | 100 | 2 | 2 | 12 | 12 | 0 | 0 | 5 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Bayer 18781..... | 96 | 20 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 64 | 12 | 5 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 18786..... | 100 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 18935..... | 100 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 2 | 2 | 5 | 5 |
| Bayer 19596..... | 100 | 12 | 7 | 15 | 15 | 5 | 0 | 2 | 2 |
| | 50 | 5 | 2 | 5 | 5 | 0 | 0 | 2 | 2 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 19641..... | 100 | 60 | 10 | 28 | 15 | 25 | 15 | 35 | 25 |
| | 50 | 15 | 5 | 12 | 10 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 19994..... | 100 | 2 | 2 | 5 | 5 | 10 | 0 | 0 | 0 |
| | 50 | 2 | 2 | 10 | 10 | 12 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 5 | 5 | 5 | 0 | 7 | 0 |
| Bayer 20172..... | 100 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 50 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 10 | 5 | 5 | 10 | 10 | 0 | 0 | 0 | 0 |

(Continued)

Table 2.--Percentage of inactive or dead and moribund insects among adult flour beetles exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after an experimental compound had been applied to the paper--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 20743 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| Dicapthon | 100 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 67 |
| | 50 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 65 |
| | 10 | 70 | 32 | 55 | 55 | 100 | 0 | 100 | 70 |
| Di-Syston | 96 | 100 | 9 | 100 | 100 | 1 | 1 | 30 | 30 |
| | 64 | 81 | 6 | 60 | 60 | 0 | 0 | 12 | 12 |
| | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| Malathion 2/ | 100 | 97 | 95 | 97 | 97 | 99 | 18 | 97 | 64 |
| | 50 | 93 | 93 | 100 | 100 | 100 | 11 | 100 | 64 |
| | 10 | 45 | 38 | 65 | 65 | 65 | 5 | 66 | 32 |
| Phostex | 100 | 5 | 2 | 10 | 10 | 0 | 0 | 0 | 0 |
| | 50 | 2 | 2 | 12 | 12 | 12 | 0 | 12 | 7 |
| | 10 | 2 | 2 | 15 | 15 | 5 | 0 | 10 | 5 |
| Sevin | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Union Carbide 8305 | 100 | 100 | 100 | 100 | 100 | 100 | 5 | 95 | 72 |
| | 50 | 100 | 100 | 100 | 100 | 95 | 0 | 92 | 52 |
| | 10 | 52 | 52 | 52 | 52 | 2 | 0 | 7 | 2 |
| Check (solvent) 2/ | 0 | 1 | 1 | 4 | 4 | 0 | 0 | 0 | 0 |

1/ I=inactive; D+M=dead and moribund.
2/ Malathion and check data are the averages from 15 tests.

Table 3.--Percentage of inactive or dead and moribund insects among adult flour beetles exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after an experimental compound had been applied to the aluminum surface

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I [1] | D+M[1] | I [1] | D+M[1] | I [1] | D+M[1] | I [1] | D+M[1] |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 13242..... | 100 | 10 | 5 | 7 | 7 | 2 | 0 | 2 | 2 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 15 | 15 | 15 | 15 | 2 | 2 | 2 | 2 |
| Bayer 16574..... | 100 | 87 | 85 | 87 | 87 | 55 | 15 | 70 | 40 |
| | 50 | 50 | 50 | 50 | 50 | 52 | 7 | 35 | 25 |
| | 10 | 2 | 2 | 5 | 5 | 22 | 0 | 10 | 10 |
| Bayer 16900..... | 100 | 97 | 97 | 97 | 97 | 20 | 7 | 23 | 8 |
| | 50 | 70 | 67 | 67 | 67 | 72 | 22 | 75 | 40 |
| | 10 | 100 | 100 | 100 | 100 | 95 | 15 | 100 | 47 |
| Bayer 16948..... | 100 | 100 | 100 | 100 | 100 | 82 | 0 | 72 | 22 |
| | 50 | 90 | 90 | 92 | 92 | 97 | 0 | 92 | 28 |
| | 10 | 72 | 72 | 75 | 75 | 100 | 0 | 100 | 28 |
| Bayer 18220..... | 100 | 5 | 5 | 10 | 10 | 0 | 0 | 0 | 0 |
| | 50 | 32 | 22 | 72 | 72 | 5 | 0 | 0 | 0 |
| | 10 | 80 | 65 | 97 | 97 | 7 | 0 | 2 | 0 |
| Bayer 18341..... | 100 | 67 | 47 | 65 | 65 | 27 | 0 | 45 | 12 |
| | 50 | 27 | 12 | 35 | 35 | 2 | 0 | 35 | 7 |
| | 10 | 0 | 0 | 0 | 0 | 47 | 0 | 40 | 7 |
| Bayer 18510..... | 100 | 100 | 100 | 100 | 100 | 100 | 12 | 90 | 40 |
| | 50 | 95 | 95 | 100 | 100 | 100 | 7 | 100 | 52 |
| | 10 | 62 | 62 | 62 | 62 | 32 | 0 | 58 | 25 |
| Bayer 18613..... | 100 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 12 | 12 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

(Continued)

Table 3.--Percentage of inactive or dead and moribund insects among adult flour beetles exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after an experimental compound had been applied to the aluminum surface--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 18780..... | 100 | 50 | 45 | 52 | 52 | 22 | 0 | 50 | 12 |
| | 50 | 72 | 70 | 75 | 75 | 42 | 0 | 52 | 18 |
| | 10 | 8 | 5 | 12 | 12 | 8 | 0 | 5 | 0 |
| Bayer 18781..... | 96 | 20 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 64 | 12 | 5 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 16 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 18786..... | 100 | 92 | 87 | 92 | 92 | 15 | 5 | 48 | 22 |
| | 50 | 77 | 77 | 82 | 82 | 62 | 0 | 62 | 22 |
| | 10 | 77 | 75 | 75 | 75 | 27 | 0 | 25 | 7 |
| Bayer 18935..... | 100 | 60 | 57 | 62 | 62 | 0 | 0 | 0 | 0 |
| | 50 | 20 | 15 | 20 | 20 | 0 | 0 | 2 | 2 |
| | 10 | 20 | 17 | 20 | 20 | 0 | 0 | 0 | 0 |
| Bayer 19596..... | 100 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 42 | 32 | 42 | 42 | 0 | 0 | 0 | 0 |
| Bayer 19641..... | 100 | 100 | 100 | 100 | 100 | 90 | 50 | 80 | 70 |
| | 50 | 92 | 72 | 80 | 80 | 50 | 20 | 55 | 40 |
| | 10 | 60 | 55 | 55 | 55 | 0 | 0 | 0 | 0 |
| Bayer 19994..... | 100 | 12 | 7 | 10 | 10 | 25 | 0 | 7 | 0 |
| | 50 | 7 | 7 | 15 | 15 | 12 | 0 | 12 | 2 |
| | 10 | 7 | 7 | 10 | 10 | 10 | 0 | 5 | 0 |

(Continued)

Table 3.--Percentage of inactive or dead and moribund insects among adult flour beetles exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after an experimental compound had been applied to the aluminum surface--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 20172..... | 100 | 22 | 22 | 27 | 27 | 5 | 0 | 0 | 0 |
| | 50 | 47 | 32 | 52 | 52 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 10 | 10 | 0 | 0 | 0 | 0 |
| Bayer 20743..... | 100 | 2 | 2 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 50 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 15 | 15 | 0 | 0 | 0 | 0 |
| Dicapthon....... | 100 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 67 |
| | 50 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 70 |
| | 10 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 62 |
| Di-Syston....... | 96 | 100 | 9 | 100 | 100 | 1 | 1 | 30 | 30 |
| | 64 | 81 | 6 | 60 | 60 | 0 | 0 | 12 | 12 |
| | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| Malathion 2/.... | 100 | 100 | 100 | 100 | 100 | 100 | 14 | 100 | 69 |
| | 50 | 93 | 93 | 100 | 100 | 98 | 8 | 100 | 63 |
| | 10 | 90 | 88 | 90 | 90 | 82 | 7 | 85 | 49 |
| Phostex......... | 100 | 82 | 82 | 82 | 82 | 12 | 0 | 17 | 17 |
| | 50 | 100 | 100 | 100 | 100 | 7 | 2 | 5 | 5 |
| | 10 | 82 | 82 | 90 | 90 | 72 | 2 | 85 | 32 |
| Sevin........... | 100 | 0 | 0 | 2 | 2 | 2 | 2 | 5 | 2 |
| | 50 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 10 | 5 | 5 | 10 | 5 | 0 | 0 | 2 | 0 |

(Continued)

Table 3.--Percentage of inactive or dead and moribund insects among adult flour beetles exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after an experimental compound had been applied to the aluminum surface--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure 24 hours | | 120 hours | | Post-exposure 24 hours | | 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Union Carbide 8305.......... | 100 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 72 |
| | 50 | 50 | 50 | 52 | 52 | 72 | 2 | 75 | 47 |
| | 10 | 52 | 52 | 52 | 52 | 30 | 2 | 30 | 17 |
| Check (solvent) 2/ | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 |

1/ I=inactive; D+M=dead and moribund.
2/ Malathion and check data are the averages from 15 tests.

Table 4.--Percentage of inactive or dead and moribund insects among adult flour beetles and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after an experimental compound had been applied to the paper

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure 24 hours | | Post-exposure 120 hours | | Post-exposure 24 hours | | Post-exposure 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 16900..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 20 | 7 | 15 | 15 | 0 | 0 | 0 | 0 |
| Bayer 16948..... | 100 | 25 | 12 | 22 | 22 | 5 | 0 | 5 | 5 |
| | 50 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 10 | 8 | 5 | 8 | 5 | 15 | 0 | 10 | 5 |
| Bayer 18220..... | 50 | 0 | 0 | 0 | 0 | - | - | - | - |
| | 10 | 0 | 0 | 8 | 8 | - | - | - | - |
| Bayer 18341..... | 100 | 0 | 0 | 7 | 7 | 0 | 0 | 0 | 0 |
| Bayer 18510..... | 100 | 0 | 0 | 5 | 2 | 2 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 |
| | 10 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 18613..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 18780..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 7 | 7 | 7 | 7 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 18786..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| | 50 | 5 | 5 | 7 | 7 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 18935..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| | 50 | 2 | 2 | 7 | 7 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |

(Continued)

Table 4.--Percentage of inactive or dead and moribund insects among adult flour beetles and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after an experimental compound had been applied to the paper--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I[1] | D+M[1] | I[1] | D+M[1] | I[1] | D+M[1] | I[1] | D+M[1] |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 19596..... | 100 | 84 | 54 | 82 | 82 | 0 | 0 | 5 | 0 |
| Bayer 19641..... | 100 | 3 | 3 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 50 | 8 | 8 | 8 | 8 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 5 | 2 | 2 | 2 |
| Bayer 19994..... | 100 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 5 | 0 | 12 | 10 | 0 | 0 | 0 | 0 |
| Bayer 20172..... | 100 | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 2 |
| Bayer 20743..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dicapthon....... | 100 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 50 |
| | 50 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 42 |
| | 10 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 37 |
| Malathion [2].... | 100 | 90 | 82 | 90 | 89 | 71 | 3 | 70 | 28 |
| | 50 | 59 | 54 | 59 | 58 | 37 | 0 | 36 | 13 |
| | 10 | 33 | 31 | 35 | 35 | 1 | 0 | 1 | 1 |
| Phostex......... | 100 | 5 | 5 | 7 | 7 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 5 |
| | 10 | 2 | 2 | 2 | 2 | 2 | 0 | 5 | 5 |
| Sevin.......... | 100 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

(Continued)

Table 4.--Percentage of inactive or dead and moribund insects among adult flour beetles and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after an experimental compound had been applied to the paper --Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Union Carbide 8305 | 100 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Check (solvent) 2/ | 0 | 2 | 1 | 2 | 2 | 0 | 0 | 0 | 0 |

1/ I=inactive; D+M=dead and moribund.
2/ Malathion and check data are the averages from 13 tests.

Table 5.--Percentage of inactive or dead and moribund insects among adult flour beetles and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after an experimental compound had been applied to the aluminum surface

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure 24 hours | | Post-exposure 120 hours | | Post-exposure 24 hours | | Post-exposure 168 hours | |
| | | I [1] | D+M[1] | I [1] | D+M[1] | I [1] | D+M[1] | I [1] | D+M[1] |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 16900..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 10 | 35 | 34 | 37 | 37 | 0 | 0 | 0 | 0 |
| Bayer 16948..... | 100 | 25 | 12 | 22 | 22 | 25 | 0 | 38 | 12 |
| | 50 | 2 | 2 | 2 | 2 | 10 | 0 | 15 | 5 |
| | 10 | 8 | 5 | 8 | 5 | 10 | 0 | 8 | 2 |
| Bayer 18220..... | 50 | 0 | 0 | 0 | 0 | - | - | - | - |
| | 10 | 0 | 0 | 0 | 0 | - | - | - | - |
| Bayer 18341..... | 100 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 |
| Bayer 18510..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 18613..... | 100 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 2 |
| | 50 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 5 | 5 | 0 | 0 | 0 | 0 |
| Bayer 18780..... | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 18786..... | 100 | 77 | 77 | 77 | 77 | 0 | 0 | 2 | 2 |
| | 50 | 53 | 53 | 55 | 55 | 50 | 0 | 47 | 20 |
| | 10 | 2 | 2 | 5 | 5 | 0 | 0 | 0 | 0 |
| Bayer 18935..... | 100 | 0 | 0 | 2 | 2 | 0 | 0 | 5 | 2 |
| | 50 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 5 | 5 | 0 | 0 | 0 | 0 |

(Continued)

Table 5.--Percentage of inactive or dead and moribund insects among adult flour beetles and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after an experimental compound had been applied to the aluminum surface--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I [1] | D+M [1] | I [1] | D+M [1] | I [1] | D+M [1] | I [1] | D+M [1] |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 19596 | 100 | 2 | 2 | 5 | 5 | 0 | 0 | 12 | 0 |
| Bayer 19641 | 100 | 0 | 0 | 7 | 7 | 2 | 2 | 5 | 2 |
| | 50 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bayer 19994 | 100 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| | 50 | 5 | 0 | 8 | 8 | 0 | 0 | 0 | 0 |
| | 10 | 2 | 0 | 18 | 10 | 0 | 0 | 0 | 0 |
| Bayer 20172 | 100 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 20743 | 100 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 |
| Dicapthon | 100 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 52 |
| | 50 | 100 | 100 | 100 | 100 | 95 | 0 | 100 | 47 |
| | 10 | 30 | 27 | 100 | 100 | 80 | 0 | 77 | 35 |
| Malathion [2] | 100 | 74 | 66 | 74 | 72 | 72 | 7 | 73 | 34 |
| | 50 | 39 | 37 | 41 | 39 | 42 | 0 | 44 | 17 |
| | 10 | 9 | 9 | 11 | 11 | 1 | 0 | 1 | 1 |
| Phostex | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 50 | 75 | 75 | 75 | 75 | 25 | 2 | 30 | 12 |
| | 10 | 72 | 70 | 75 | 70 | 32 | 2 | 32 | 12 |
| Sevin | 100 | 12 | 12 | 15 | 15 | 0 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 25 | 25 | 0 | 0 | 0 | 0 |
| | 10 | 15 | 15 | 15 | 15 | 0 | 0 | 0 | 0 |

(Continued)

Table 5.--Percentage of inactive or dead and moribund insects among adult flour beetles and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after an experimental compound had been applied to the aluminum surface--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Post-exposure | | | | Post-exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 168 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Union Carbide 8305.......... | 100 | 12 | 12 | 12 | 12 | 7 | 0 | 0 | 0 |
| | 50 | 2 | 2 | 5 | 5 | 7 | 0 | 0 | 0 |
| | 10 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| Check (solvent) 2/ | 0 | 1 | 1 | 5 | 4 | 0 | 0 | 0 | 0 |

1/ I=inactive; D+M=dead and moribund.
2/ Malathion and check data are the averages from 13 tests.

Table 6.--Percentage of inactive or dead and moribund insects among adult flour beetles and black carpet beetle larvae exposed to vapors of an experimental compound

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Exposure 24 hours | | Exposure 120 hours | | Exposure 24 hours | | Exposure 360 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Bayer 13242..... | 192 | 100 | 57 | 100 | 100 | 0 | 0 | 10 | 5 |
| Bayer 16574..... | 192 | 100 | 95 | 100 | 100 | 100 | 0 | 100 | 95 |
| Bayer 16900..... | 200 | 100 | 100 | 100 | 100 | 95 | 0 | 100 | 92 |
| Bayer 16948..... | 200 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 100 |
| Bayer 18220..... | 200 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 18341..... | 200 | 5 | 0 | 25 | 25 | 0 | 0 | 38 | 20 |
| Bayer 18510..... | 200 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 18613..... | 200 | 0 | 0 | 2 | 2 | 17 | 0 | 50 | 45 |
| Bayer 18780..... | 200 | 0 | 0 | 45 | 40 | 0 | 0 | 100 | 100 |
| Bayer 18781..... | 192 | 0 | 0 | 0 | 0 | 2 | 0 | 10 | 10 |
| Bayer 18786..... | 200 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| Bayer 18935..... | 200 | 0 | 0 | 66 | 56 | 0 | 0 | 12 | 10 |
| Bayer 19596..... | 200 | 0 | 0 | 60 | 60 | 95 | 0 | 100 | 68 |
| Bayer 19641..... | 200 | 0 | 0 | 70 | 45 | 0 | 0 | 100 | 100 |
| Bayer 19994..... | 200 | 2 | 2 | 7 | 7 | 0 | 0 | - | - |
| Bayer 20172..... | 200 | 0 | 0 | 62 | 62 | 0 | 0 | 87 | 47 |
| Bayer 20743..... | 200 | 67 | 37 | 100 | 100 | 17 | 0 | 100 | 92 |

(Continued)

Table 6.--Percentage of inactive or dead and moribund insects among adult flour beetles and black carpet beetle larvae exposed to vapors of an experimental compound--Continued

| Compound | Rate of application | Effect of compound on -- | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flour beetle adults | | | | Black carpet beetle larvae | | | |
| | | Exposure | | | | Exposure | | | |
| | | 24 hours | | 120 hours | | 24 hours | | 360 hours | |
| | | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ | I 1/ | D+M 1/ |
| | Mg./sq. ft. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. | Pct. |
| Dicapthon | 200 | 37 | 20 | 100 | 100 | 100 | 0 | 100 | 77 |
| Di-Syston | 192 | 100 | 100 | 100 | 100 | 100 | 2 | 100 | 100 |
| Lindane 2/ | 200 | 100 | 75 | 100 | 100 | 82 | 2 | 100 | 98 |
| Malathion 2/ | 200 | 44 | 31 | 100 | 100 | 64 | 4 | 100 | 85 |
| Phostex | 200 | 2 | 2 | 72 | 60 | 0 | 0 | 22 | 7 |
| Sevin | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 28 |
| Union Carbide 8305 | 200 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 95 |
| Check (solvent) 2/ | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 6 | 3 |

1/ I=inactive; D+M=dead and moribund.

2/ Malathion, lindane, and check data are the averages from 14, 18, and 18 tests, respectively.

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